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INDUSTRIAL RESEARCH AND THE UNIVERSITY

Institutions of higher learning are, *per se*, concerned with knowledge and its uses, with its impartation and extension. In the furtherance of these functions, colleges and universities have long devoted careful attention to both education and research, fields of overlapping and mutually beneficial influences.

In recent years, many universities, especially technological institutions, have offered their rather unique research services to those about them who have need of such assistance. These ventures into the fields of "industrial" research differ in several ways from the otherwise related endeavors of private consultants, regional research groups, and even the private (company) research laboratories. While this subject has been much discussed, it nevertheless seems timely to restate briefly the reasons for university industrial research and, more specifically, to redefine the industrial research functions of university engineering experiment stations.

These stations seek primarily to aid those companies, individuals, industrial groups, government agencies, and others who do not possess their own research facilities or whose laboratories are not equipped for work on specific research problems. They do not provide such assistance in competition with the well-equipped laboratories of those companies large enough to afford them, or with private consulting laboratories. Instead, their aim is to complete the picture; to render service where the

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An opportunity to conduct research is of exceeding importance to many members of the faculty of such technological institutions as Georgia Tech. To the teacher, the quest for new facts stimulates interest in his field, broadens his grasp of related subjects, and increases his ability to conduct further research, thereby improving his proficiency in imparting information and training to his students. To the scientists and engineers on the staffs of the research institutes sponsored by many technological universities, research is their prime interest and skill, hence its conduct is necessary to attract and hold them; their presence on the educational scene makes possible graduate programs of broader scope and otherwise greatly increases a university's educational potential.

Some wit once remarked: "Those who can, do; those who can't, teach." If this were ever true, it can be disproved today by pointing to the many prominent scientists and engineers who devote their efforts to a combined program of education and research on the faculties of many institutions of higher learning. Teaching itself offers many challenges to a man who has mastered a field sufficiently to impart knowledge to others; when that opportunity is combined with the chance to perform important and useful research, there is much to attract a man to such institutions as Georgia Tech. It is our aim to continue to make our program attractive to our faculty, so that it may render outstanding educational and research service.

BLAKE R. VAN LEER
President, Georgia Institute of Technology

PHOTOGRAPHY — A VERSATILE RESEARCH TOOL

By J. E. GARRETT*

Tremendous strides have been made in the past few years in the development of photographic techniques. As a result of these technological advances, photography is being utilized more and more as a research tool, in many instances to obtain data which were not heretofore available. A brief description of some of these uses is presented in the following article, together with the part that the Engineering Experiment Station's Photographic and Reproduction Laboratory is playing in applying photography to research problems at Georgia Tech.

Although photography is by no means a new science (the principle underlying the operation of the predecessor of the modern camera, the *camera obscura*, having been first mentioned by Aristotle in about 350 B. C.), its importance as a research tool has only been recognized during the past two or three decades.

PHOTOGRAPHIC FUNDAMENTALS

Photography has been defined as "the process of producing images on sensitized surfaces by the action of certain electromagnetic waves." The electromagnetic waves or radiations which may be used for this purpose include gamma rays, X-rays, infrared rays, and those radiations commonly referred to as ultraviolet and visible light. The best evidence available indicates that all of these radiations as well as those which cannot be detected by photographic means (radio and Hertzian waves) are basically the same, differing from one another only in their wavelengths. These latter are usually expressed in angstroms (A), a very short unit of measurement equal to 10^{-7} millimeters.

The photographic process also includes the development and fixing of such images as well as their transference to other sensitized surfaces; however, a discussion of these phases is somewhat beyond the scope of this presentation.

RESEARCH USES

The present-day uses of photography in research are manifold, although they may be divided into two separate (but frequently overlapping) classes. The first of these is the employment of the camera, usually in conjunction with other instruments, as a substitute for the human eye. Here, photography finds wide usage in such fields as spectroscopy, radiography, microradiography, X-ray diffraction, and profilography. In the second broad use, the camera is used to record experimental results which are visible to the human eye; this use is made either solely for the establishment of permanent records or to enable more exact comparisons to be made with the results of subsequent experiments. Also included in this category is the recording of all types of information for record purposes.

SPECTROSCOPY

When light from a source such as the sun is passed through a prism, it is resolved into its component colors — violet, red, blue, etc. This broad colored band is known

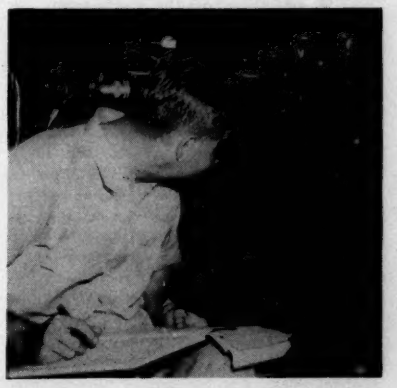

Figure 1. In research operations which involve the use of an oscilloscope, it is of great value to the worker to be able to photograph the oscilloscope image at any given time. Shown above is a research worker using an oscilloscope connected with a special camera which makes possible such records.

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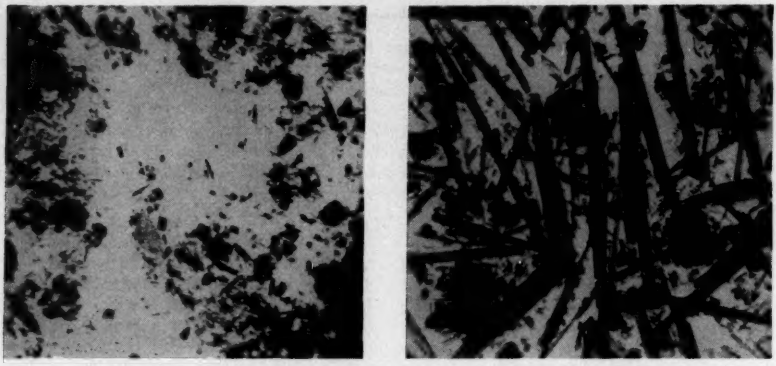

Figure 2. Electron micrographs (9,000 x) of a synthetic manganese dioxide sample, before (left) and after (right) an oven conversion. Such research records make possible the development of new theories and the understanding of basic differences.

as the visible spectrum and is considered to consist of those radiations whose wavelengths lie roughly between 3,900 and 7,600 angstroms. However, the presence of ultraviolet radiations (wavelength = 136–3,900 A) cannot be detected in this manner as they are not visible to the human eye.*

The operation of the spectograph, an instrument which functions in a manner somewhat analogous to a prism, is based upon the fact that each of the known elements, when heated to incandescence, emits light which is distributed over the spectral range in a different manner and to a different degree from that of any of the other elements.[1] Therefore, in the spectrograph, the radiations given off by heating to incandescence a sample of a given material are passed through a system of lenses and mirrors which serve to separate them into a series of varicolored spectral lines. This image is recorded upon a photographic plate, and the elements present in the sample under investigation may then be determined from the relative positions of the spectral lines. The use here of photography serves the double purpose of providing a permanent record and of permitting the detection of the very useful ultraviolet spectral lines which are not a part of the visible spectrum. Spectroscopy is particularly useful in the analytical field, since the composition of comparatively complex mixtures can be determined rapidly and accurately by its use.

RADIOGRAPHY

Photography has been used for many years in the medical field to record the impingement of X-rays which have passed through portions of the human body. In recent years, however, a similar process utilizing these rays (wavelength = 0.1–1,000A) has been perfected for industrial and non-medical research use. By using this process, which consists essentially in placing the substance to be tested, for example a metal casting or a welded joint, between a source of X-rays and a photographic plate, a "picture" of certain conditions existing within opaque objects may be obtained. By the use of intensifying (fluorescent) screens, one of the few objections to this process, namely, the comparatively long exposure time required, has been eliminated. Also, the employment of a combination of X-rays and a sensitive photographic emulsion makes possible the detection of otherwise hidden structural defects by a rapid, nondestructive method that can be applied to a wide variety of materials.

The use of X-rays for the detection of flaws in objects of various kinds, as de-

* Ultraviolet radiations can, however, be photographed.

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FINE PARTICLES RESEARCH AT GEORGIA TECH

By J. M. DALLAVALLE*

The growing importance of the behavior of fine particles has been acknowledged in recent years by the addition of a new word — micromeritics — to the lexicon of the scientist, the engineer, and the industrialist. The following article traces the growth of the science of micromeritics, points out why the behavior of fine particles is of almost universal importance, and describes the research program which was recently initiated at Georgia Tech in this rapidly developing field.

Many phenomena of common everyday occurrence and most industrial processes involve some aspect of the behavior of fine particles. In fact, it would not be difficult to show that our very existence is much affected by small particles and that we cannot very well get along without them.

The universality of fine materials — the soil, dust, and breakfast cereals — frequently leads us to subordinate the role which they play in making this earth a habitable place. Without fine particles there could be no agriculture and no variegated sunsets; and breakfast cereals, bad as they seem to some, would taste still worse.

APPLICATIONS

The characteristics of many substances vary with their degree of fineness. For example, the finer the particles of the soil, the better the capillarity by which moisture is brought from the wetter regions below the surface to plant roots. Similarly, finely divided soils have increased moisture-holding capacity and mineral solubility, affording more food to the plants. Certain foods can be made to taste differently according to the degree to which they are ground. This is true of cereals, peanuts, and chocolate — to mention three items familiar to all.

Many industrial processes involve consideration and use of materials in a fine state of subdivision. Typical industries in which this is true are cement, ceramics, plastics, pigments, paper, and petroleum. For the chemical industry, with its many and complex ramifications, several pages would be required just to list the processes which require fine particles either to promote reactions or as intermediate or end products. One needs only to mention catalysts, absorbents, crystallizers, and filtrants, without which the chemical industry could hardly begin to meet the demands imposed upon it in this day and age. The effectiveness of these components depends on the particles composing them, and their size.

However, while fine particles possess many valuable attributes, they also create many problems, some of them of exceedingly great magnitude. Soil is easily eroded by wind and rain; reservoirs fill with sedimented silt and reduce the holding capacity of dams; deserts have a habit of growing; and dust and smoke are detrimental and give rise to a host of nuisance problems. Fine particles thus assist us only so long as we control their uses and the manners in which they are formed.

MICROMERITICS

Since fine particles act in so many ways, it seems logical that there must be underlying reasons for their behavior in different circumstances. The study of the laws of particulate behavior forms the science of *micromeritics* — the technology of fine particles. This science deals with measures of particle shape and size; aggregates and packings; electrical, chemical and physical properties; and, in fact, all of the factors which tend to explain phenomena associated with fine substances. By understanding the properties of a given powder, one can better control a product or achieve a desired end result.

Only during the past few years has any serious attempt been made to study the characteristics and behavior of fine particles in a systematic manner. A good deal has long been known about those minute particles called "colloids," but particles larger than these, ranging from the submicroscopic

* *Associate Professor of Chemical Engineering.*

to those easily seen (individually) by the naked eye, are less understood even today.

Micromeritics can be said to be the outgrowth of agricultural and industrial developments, a result of the need to correlate data relative to the behavior of small, irregular particles. No date can be set as to when the science began to take shape, although it might be presumed that interest in the subject began with the development of soil physics, sometime during the 18th Century. It was not until the early years of the present century, however, that a systematic study of the foundations of the subject was undertaken and applied not only to agriculture, but to all fields which utilize fine particles. Among the pioneers in micromeritics may be mentioned Svedberg and Atterberg in Sweden, Keene and Russell in England, and Hilgrad, Buckingham, and Hatch in the United States. It may be noted, incidentally, that during the past ten years more papers dealing with fine particles have appeared in the technical journals than were published during the previous 200 years. The greatest progress, moreover, has been made by American investigators.

MEANING OF PARTICLE SIZE AND SHAPE

It is quite difficult to define a particle satisfactorily. Usually, it is considered to be a granular substance of irregular shape. However, it is possible for particles to have regular shapes such as, for example, those of a sphere or a cube. If a particle is irregular, there is no way of measuring its volume or surface by means of a single dimension or any combination of dimensions. The volume of an irregular particle may be determined by displacement if it is large enough to be handled conveniently, but there is no such simple method for measuring its surface. Moreover, what about very small particles which are submicroscopic in size? Their volume and surface are especially important, but how are they measured and what is the significance of the results obtained? Are such data relative or absolute?

While it might be presumed that the complications involved in measuring the properties of a single particle are intensified when dealing with an assemblage of particles, this is fortunately not the case — actually, the problem of measuring volume and surface is much simplified. In fact, no less than 20 statistical methods may be applied to the measurement of surfaces and volumes of particle assemblages. Not all of these methods yield the same results, nor are they always consistent among themselves for a given assemblage of particles. Some interpretation of data is therefore necessary, and this is supplied by micromeritics.

For example, consider the measurements of particle diameter based on two different methods, say of two suspensions, one of which is so arranged that one can observe change in density and the other set up so as to make possible detection of any change in transmitted light. In the first case, one actually measures a settling rate, assuming that the particles settle as though they are spheres of equivalent diameter and density, while in the second, one measures difference in light intensities caused by absorption by particulate *surfaces*. Thus, settling rate experiments measure diameter as a function of mass, and turbidimetry measures diameter as a function of surface. The result in each case may differ considerably, so that unless the method of measurement is known, one might draw erroneous conclusions from particle size values. Diameters calculated by turbidimetry are better measures of the surface of irregular particles than are those obtained by gravimetric procedures; conversely, if one is interested in the mass of an average particle, the settling rate method is to be preferred.

Another example may serve to show the necessity of knowing the size distribution of the particles under study. The statement that two materials passing through a pair of sieves are retained on a third will have the same size is incorrect unless it is known how the particles are individually distributed as to size. Sieves do not define the size fractions of a material as sharply as is frequently assumed; further measurement by microscopic techniques reveals significant differences. Figure 1 shows two materials which passed through a 270-mesh sieve and were retained on a 325-mesh sieve. Both materials have the same *average* particle size, but even casual inspection will show that they actually do not appear to be the same

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MODERN SANITARY SUPPLIES

By HAROLD B. FRIEDMAN*

Chemical product industries are highly prized in every region of this country. In this connection, however, it is all too easy to overlook the producers of products of such wide use that they are taken almost for granted — sanitary supplies. Georgia, and Atlanta in particular, is fortunate to possess several local manufacturers of such materials, and the following article presents a description of certain aspects of this important field.

In contrast to such mighty industries as steel, petroleum refining, or automobile manufacture, the sanitary supply business is but a lusty infant. However, it is an infant which is growing rapidly and which already has achieved a position of importance as to size, dollar value of its manufactured products, and significance to our daily life.

An important part of the history of mankind has been the constant struggle against disease. The importance of cleanliness and its relation to health passed almost unnoticed through the Middle Ages, even when death and destruction rode triumphantly on the wings of the Black Plague, which took millions of lives in Europe alone. It remained for Pasteur to establish the germ theory of disease and for Lord Lister to introduce antiseptics into surgery even before Pasteur's work had been verified. Even then, no thought was given to the use of disinfectants to destroy pathogenic or harmful organisms.

Even after a direct connection was recognized between sanitation and health — the word sanitation is derived from the Latin *sanitas*, meaning health — the esthetic side of cleaning was long ignored, particularly when applied to industrial cleaning. Only comparatively recently have modern construction and new types of installations invited and encouraged management to provide clean and more attractive places in which to work. Government inspection requirements in connection with the processing and packaging of food products have compelled food processors to keep their plants clean as a preventive against contamination of products by filth, insects, rodents, or other undesirables.

The public has in general become more "sanitation conscious." Retail management has come to appreciate that clean, modern, attractive stores are more inviting to customers. Manufacturers have recognized that more efficiency and greater production result from plants that are kept clean, and that sanitary rest rooms mean less time lost due to sickness and infection of workers.

The sanitary supply industry has not been slow to take advantage of this interest in its products. As the need arose, new products have been quickly developed. Facilities for their production have been expanded, and the expected sequence of product improvement and standardization has followed. However, much of the growth and development in the industry is of compara-

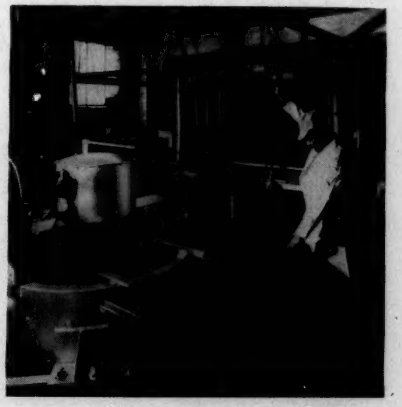

Figure 1. Manufacturing paste soap in a soap crutcher.

* *Chemical Director, Zep Manufacturing Company, Atlanta, Georgia.*

Figure 2. Drawing liquid cleaners from mixing tanks.

tively recent origin. As recently as 25 years ago, the industry had quite a different character than it has at present. Disregarding any consideration of products for individual household use, which field is outside the scope of the present discussion, industrial sanitation of a quarter century ago provided relatively few outlets for sanitary products, particularly in the South. These outlets were restricted to the few large industrial installations which were then located in this area and to such cities, counties, or municipalities as were concerned with lessening the unattractiveness of their installations or covering up offensive odors in their public buildings, prisons, or convict camps. It was still the era of the brass spittoon and the outside pit toilet.

Sanitary supplies then available were also limited in their variety. There were, of course, plenty of scrub soap, of questionable quality, and heaps of sweeping compound for laying dust. The only disinfectant available in any quantity was "black disinfectant," a water-emulsifiable coal tar liquid which was strong in odor if not in bactericidal effect. This was poured about indiscriminately in a righteous effort to combat disease. Wax was dispensed either in the form of a paste or as a thick liquid dispersion in a kerosene or mineral spirits base. These were adequate for wood floors if they were smooth and well-finished, but the paste wax was troublesome to apply, and both the paste and the liquid required buffing to produce a luster. Rough wooden floors were generally oiled; this tended to prevent dustiness but added materially to their flammability. In general, the lack of attractiveness of the surroundings was not conducive to much maintenance. The latter was largely a matter of removal of the larger trash, frequent sweeping, and occasional scrubbing.

MODERN WAXES

Notable changes took place in the late 1920's with the advent of wide use of composition floors. One of the first of these newer types of flooring material, and still one of the most common, was asphalt tile. This type of flooring is conveniently laid in squares 9 to 12 inches on edge, and its variety of colors makes possible a number of designs and patterns of pleasing appearance. Its immediate effect on the sanitary supply industry was the requirement for a different type of wax, for both the paste and the mineral-spirit liquid waxes have a deleterious effect on the asphalt tile, which quickly softens and eventually dissolves when exposed to mineral spirits.

To meet the need, commercial emulsions of wax in water were developed. Such products do no harm to any type of floor, either wood or composition; are easy to apply; and dry with a luster; that is, they are "self-polishing." Carnauba wax, a natural product secreted by a type of palm tree which grows in Brazil, is generally the base wax employed. The refined wax is hard and must be melted, then emulsified in water. The addition of certain natural or synthetic resins frequently contributes desirable qualities to the finished emulsion; the emulsifying agent commonly employed is soap or a soap-type material.

The finished wax emulsion must be stable after prolonged storage; it must have proper flow characteristics, so that it will not streak upon application to a floor; its dispersed wax particles must be of the optimum size to give good gloss; it must dry to a hard, nonbrittle film so as to give good wear resistance, yet be soft enough to permit the scuff marks of traffic to be buffed or polished out; and it must be water-resistant when dry, so that it will not re-emulsify when scrubbed with soap and water, yet must still be capable of being removed at the proper intervals when it is desired to strip the floor before rewaxing. Many of the waxes on the market fall far

short of meeting one or more of these requirements.

Other types of composition floors quickly followed those of asphalt tile, so that there are now a wide variety for many uses.

LIQUID SOAPS

While much hard bar soap is used in industry, it is safe to say that for industrial cleaning the soft or potash soaps play the more important role. These are available in the form of liquid soap solutions up to an anhydrous soap content of 40 per cent, above which concentration they become jellies or pastes with soap contents up to approximately 80 per cent. Soda soaps become jellies before a 40 per cent concentration is reached unless a considerable portion of coconut oil is employed. Liquid hand soaps for use in soap dispensers are made largely from this oil. Careful control is necessary to insure that such soaps are natural in the sense that they do not contain free alkali or fatty acids. As regards the ordinary liquid scrub soaps, these may vary from this same neutrality up to strongly alkaline solutions which may be "built" with added alkali salts such as sodium metasilicate, sodium phosphate, sodium carbonate, or the like, depending upon the type of surface upon which they are to be used and upon the difficulty of removal of the particular soil. The paste or jelly soaps constitute a more concentrated form of cleaner and are dissolved in water by the user, as needed.

The alkalis used in the manufacture of these soaps are principally caustic potash, with possibly some caustic soda or the alkaline salts previously mentioned. The oils commonly employed may be, besides coconut, soybean, cottonseed, corn, tallow or other animal fats, tall oil (a by-product from pulp mills, resulting from the digestion of the pulp), and the like. The fatty acids of the above oils are occasionally used instead of the oils themselves.

SYNTHETIC DETERGENTS

Supplementing and to some extent replacing soap in the cleaning field are the so-called "synthetic detergents." These materials possess a distinct advantage over soaps in that their calcium, magnesium, and iron salts are not insoluble like those of soaps; consequently, no objectionable precipitation occurs in hard waters containing these metals. Moreover, many synthetics have cleansing actions equal to or superior to that of soap.

The earliest types of these synthetic detergents, first used in Germany, were sulfated or sulfonated higher alcohols, hydrocarbons, or amide condensation products. Now, many hundreds of such compounds are being made commercially with varying properties and uses for different operations. Most of these are of the "anion-active" type, so called because they have a complex negative ion or anion in their molecule, of which they are usually the sodium salt. One of the most effective of these, now produced in large volume, is the sodium salt of an alkyl aryl sulfonate. These detergents can usually be prepared in powder, paste, or liquid form. Many common washing powders, shampoos, and dentifrices contain members of this class of compounds.

Most of the common "cation-active" detergents, which have a complex positive ion, are quaternary ammonium chlorides. These compounds are quite soluble in water and have some cleansing action. Their chief advantage, however, is the fact that they are potent germicides and therefore disinfectants; this will be mentioned again under the discussion of disinfectants. In solution, these compounds find use as excellent cold sanitizing rinses for dishes, food utensils, hospital equipment, surgical instruments, and the like. They are effective in high dilution, and are excellent deodorants. While odor-

Figure 3. Partial view of Zep developmental laboratory.

less themselves, they act to destroy bacteria which produce odors. Thus they do not cover up one odor with another, but destroy objectionable odors without leaving one.

A third class of the synthetic detergents is the so-called "nonionic" type, compounds whose complicated molecules produce no ions in solution. Many of these substances have good cleaning qualities and, like the other detergents, have good foam-producing qualities. Foaming, incidentally, is often of more psychological than actual importance to the user of cleaning materials.

In a relatively short time the synthetic detergents have, as mentioned, made a real place for themselves in the cleaning field. Their adoption was to some extent accelerated by the wartime soap shortage which resulted from the scarcity of natural fats. Although this shortage has since abated, several advantages of the synthetic detergents have enabled them to maintain a position of growing importance, and their annual production is steadily increasing. In terms of effectiveness, the costs of many of them are now as low as or lower than that of soap. While some detergents, such as the quaternary ammonium compounds, are still relatively high-priced, their potency as disinfectants is often such as to render them economic.

OTHER CLEANERS

Powdered cleaning mixtures are important items in the sanitary supply field. These consist of mixtures of various alkalies or alkaline salts, with or without the addition of powdered soap or synthetics. As examples there may be cited the various washing powders, grease emulsifiers for concrete and other types of hard floors, dishwashing compounds for hand or machine dishwashing, car and truck washes, automotive degreasers for cleaning engines and the under parts of chassis, and so on. A few acidic cleaners are employed, but to a greatly limited degree, because of the highly corrosive action of acids. In addition to these are the chlorine-containing compounds, the hypochlorites, for cleaning, bleaching, and deodorizing.

DISINFECTANTS

No discussion of the problems of the sanitary supply industry would be complete without mention of the disinfectants. One of these, black or coal-tar disinfectant, has already been mentioned as an early participant among sanitary products. While large quantities of this product are still being sold, it is losing its relative place to disinfectants of greater effectiveness or of less objectionable odor for indoor use. Pine disinfectants or solublized pine oil are among these. These products chiefly contain pure, steam distilled pine oil, with enough added soap and a small percentage of water so that when the mixture is poured into a larger quantity of water, it forms a stable, milky emulsion of pleasant odor and effective disinfecting power.

The quaternary ammonium compounds have already been discussed with reference to their disinfecting qualities. Their use for this general purpose is steadily growing. Other preparations of significance for inanimate sanitizing contain chlorinated phenols or compounds of the type of sodium ortho-phenyl phenol, chlorine-containing compounds of varying degrees of stability such as chloride of lime, true calcium hypochlorite, compounds of the chloramine B and chloramine T types, succinchlorimide, and so on.

INSECTICIDES

In the field of industrial sanitation, a wide variety of insecticides is being employed. No reference to agricultural insecticides need be made here, since these are not commonly handled by sanitary supply houses. DDT (dichlorodiphenyltrichloroethane) has received by far the greatest amount of publicity. This substance has excellent killing power against most of the nonscaly types of insects, but it suffers from the limitation of having little or no knockdown power. Pyrethrum, extracted from a type of flower grown in Japan, eastern Europe, and Africa, has effective knockdown and is frequently used in combination with DDT. However, several synthetic products have been developed which are as effective for this purpose as pyrethrum. A typical example of these is isobornylthiocyanoacetate. Chlordan, a chlorinated aromatic hydrocarbon, is especially effective against roaches and many other insects.

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The following index for the first three annual volumes of THE RESEARCH ENGINEER comprises a combined subject and author index to material contained in these volumes. As may be noted, these index pages are unnumbered and may be removed from this issue if desired.

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DIGESTS OF GRADUATE THESES

MISCELLANEOUS FIELDS

1947–1948

The following digests represent summaries of theses submitted during 1947–48 in partial fulfillment of the requirements for the degrees of Master of Science in Chemistry, Master of Science in Mechanical Engineering, Master of Science in Physics, and Master of Science in Textile Engineering. This is the last in a series of features designed to present data on the graduate theses submitted last year to the various schools of the Georgia Institute of Technology.

CHEMISTRY

Howard Smith McCullough, *Quinaldinecarboxylic Acids by the Pfitzinger Reaction.* Faculty advisor: Dr. Paul K. Calaway.

The quinoline nucleus with various substituents has exhibited therapeutic value in a number of cases. Examples are cinchopen, for rheumatic fever and gout; yatren, for amœbic dysentery; vioform, as a substitute for iodoform; and plasmochin and quinine, as anti-malarials. The purpose of this investigation was to prepare a number of substituted cinchoninic acids that were closely related in structure to these chemotherapeutic agents.

These substituted chinchoninic acids were prepared by condensing various aryl propanones with either 5–methyl– or 5–chloroisatin. The experimental conditions used for these condensations are described, as is the preparation of the intermediate propanones and isatins. A total of six different arylpropanones was prepared; these were condensed with the isatin compounds to form 11 different substituted chinchoninic acids. Yields of the acids varied between 18.6 and 83.7 per cent of the theoretical. *E.P.C.*

Robert Lewis Sublett, *Alkoxyaryloxyketones and Their Condensation with Isatins.* Faculty advisor: Dr. Paul K. Calaway.

The availability of alkoxyketones from chloroacetone and alkoxyphenols suggested their condensation with isatin as a continuation of the work of Henze, Calaway, and coworkers who have extended the Pfitzinger reaction for the preparation of quinoline derivatives by the condensation of isatins with ketones.

Experiments have shown that the quinoline group may exhibit marked pharmaceutical properties. Examples of substituted quinolines, whose effectiveness as antimalarial drugs has been proven, are cinchopen, plasmochin, atoquinol, and quinine. Nupracaine is an example of a substituted quinoline which has anesthetic properties.

The substituted cinchoninic acids reported in this thesis are related in structure to these chemotherapeutic agents and therefore may be of interest in the field of chemothrapy. *M.B.*

Francis Xavier Walsh, *3-Arylmercapto-4-Quinaldine Carboxylic Acids.* Faculty advisor: Dr. Paul K. Calaway.

Experiments have proved the activity of the quinoline group in contributing to the chemotherapeutic effectiveness of various medicinal agents, particularly in the antimalarial properties of quinine. This activity has also been demonstrated by the use of other substituted quinoline compounds such as plasmochen, cinchopen, and atoquinol in chemotherapy. The purpose of this investigation was to prepare a series of substituted quinoline acids by condensing either 5–chloro– or 5–bromoisatin with a number of arylmercaptopropanones.

The preparations of the haloisatins and of the arylmercaptopropanones used are described in some detail, as is the preparation of the substituted quinoline acids from these intermediates. A total of eight substituted quinoline acids were prepared, with yields varying between 40.1 and 73.7 per cent of the theoretical. No melting points could be determined, due to the failure of the compounds to melt sharply. *E.P.C.*

MECHANICAL ENGINEERING

Clarence Robinson Weeden, *A Study of Rates of Flow Through Certain Types of Moving Parts.* Faculty advisor: Professor R. L. Allen.

In all existing intermittent fluid-metering devices whose discharges are accompanied by a large pressure drop, there is generally either a mechanically or hydraulically operated reciprocating valve. Mechanically or hydraulically actuated intermittent fluid-metering valves have, however, either inertia lags or pressure-wave disturbances when operated at high frequency, since the fluid, before emission, is retained under compression. These disadvantages in existing intermittent metering valves are serious, and, in some instances, no cure or solution is apparent.

It was believed that a better high-pressure, intermittent fluid meter might be developed through the positive regulation of the action of a rotated port passing an orifice. The original design of a fluid-metering device built by the student and a study of the intermittent flow of an oil from it are presented in this thesis.

Four objectives were selected as the basis for this thesis, as follows: (1) to design an intermittent-flow, high pressure-drop oil-metering device which would expel the oil from an orifice without the complication of the conventional, spring-loaded, injection-nozzle reciprocating valve; (2) to produce a rotating-port oil-metering device with an orifice which would emit a measured discharge during a fraction of each cycle, then cut off that slug, expel it, and have no after-dripping following a discharge; (3) to determine the quantity of oil discharged per cycle from a certain orifice when the oil was caused to flow by a known pressure drop; and (4) to study the characteristics of discharge from the orifice by visual and photographic aids. *M.B.*

PHYSICS

Robert Wayne Koza, *A Study of Hypotheses on the Role of Electrical Forces in Mitosis.* Faculty advisor: Dr. J. E. Boyd.

During the past 50 years a number of hypotheses have been advanced concerning the part played by electrical forces in the process of mitosis. The purpose of this study was to ascertain the exact scope of these hypotheses and to evaluate them in terms of the experimental facts as they are now known. It was hoped that such a review and evaluation would indicate the most desirable course for future study and experimentation on this problem. In this study, the term mitosis was used to include all nuclear divisions that involve the equal partition of the chromosomes to the daughter nuclei.

The process of mitosis was reviewed, with both typical and atypical phenomena being considered. The various hypotheses concerning the role of electrical forces in mitosis were reviewed in the order in which they were proposed. Experimental findings in support or refutation of a particular concept were included with the discussion of the hypothesis. The hypotheses and the experimental findings were then compared and evaluated, with the result that it was concluded that they remain as hypotheses. A great deal of experimental evidence can be cited to support or discredit these hypotheses, but decisive evidence is lacking. Therefore, it is apparent that the electrical hypotheses warrant further serious consideration.

E.P.C.

TEXTILE ENGINEERING

Ralph Lenton Hill, *Studies of Single End Sizing of Cotton Yarns.* Faculty advisor: Dr. J. L. Taylor.

The goal of every cotton mill that makes cloth is to obtain a perfectly sized cotton yarn. The usual method of sizing cotton yarn is to apply a hot size mixture to the yarn and then dry the yarn on hot cylinders or in hot air. The object of this investigation was to find a suitable method of single end sizing of cotton yarn which will give the optimum conditions of elasticity, smoothness, and tensile strength in the sized yarn.

The procedure followed in this study included preliminary test runs to determine the optimum conditions for spinning the best quality of yarn from a standard size and quality of roving in the creel. The most suitable method of applying the size compound to the yarn was then determined, after which the most promising of a number of size compounds was determined. Finally, a group of experiments was made using five superior types of size compounds.

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RECENT STATION PUBLICATIONS

The following publications have been released by the Station since those reported in the November, 1948, issue of THE RESEARCH ENGINEER. Single copies of gratis issues may be obtained by writing to the Station's Technical Information Division; other publications are available at the prices stated.

CIRCULAR

B. H. Weil, *Antifreezes fro mPetroleum*, Georgia Institute of Technology, State Engineering Experiment Station Circular No. 25, 1949. 6 pages. Gratis.

This paper, reprinted from the January, 1949, issue of *Petroleum Processing*, analyzes the required properties and characteristics of antifreeze materials. Following this, description is made of those antifreezes actually in use, with a discussion of their merits and demerits. The popular antifreeze compounds — methanol, ethanol, isopropanol, ethylene glycol, and propylene glycol — are all produced largely from petroleum fractions, and this article describes the principal methods of synthesis and lists the current producers. Price and production statistics of all antifreeze materials are given, along with an economic discussion of the over-all field.

REPRINTS

W. T. Ziegler, *Georgia Tech Constructs New Low Temperature Laboratory*, Georgia Institute of Technology, State Engineering Experiment Station Reprint No. 29, 1948. 3 pages. Gratis.

This article, reprinted from the November, 1948, issue of *Refrigerating Engineering*, briefly reviews current low temperature research and its applications, after which it presents a description of the Georgia Tech Low Temperature Laboratory. Following a description of the purposes and general facilities of this laboratory, brief descriptions are given of its hydrogen gas purifier and liquefier, its helium cryostat, its liquid nitrogen plant, and other special facilities.

B.H.W.

George W. Reid and Robert S. Ingols, *Rapid Analytical Techniques for Water and Sewage Analysis*, Georgia Institute of Technology, State Engineering Experiment Station Reprint No. 30, 1949. 4 pages. Gratis.

This progress report on the Georgia Tech research on "rapid chemical and physical analytical techniques in water and sewage analysis," a project undertaken under a grant from the United States Public Health Service, describes the accomplishments and current plans of this project. Attempts have been made to devise new and suitable analytical techniques, as well as to modify existing pertinent ones. An oxygen consumed technique has been developed, a fundamental study has been undertaken on several methods of determining fluoride ions, and a ferric thiocyanate determination has been developed sufficiently for use in testing several natural waters.

According to this article, which appeared in the January, 1949, issue of *Public Works*, studies on total nitrogen determination by the microkjeldahl procedure have been completed, and studies on chromium, nitrate, and sulfate ion determinations have been inaugurated. Some fundamental studies on the entire B. O. D. problem, including development of a photometric end-point method for the relative stability tests, have established patterns for future studies, including B. O. D. tests with blended sewages and direct B. O. D. studies with the Sierp apparatus. A bibliography of the literature on water and sewage analysis has been compiled and published.

W. H. Burrows, *Graph Papers as Instruments of Calculation*, Georgia Institute of Technology, State Engineering Experiment Station Reprint No. 31, 1949. 13 pages. 25 cents.

The nomograph is a standard tool of the engineer in the solution of problems based upon specific engineering formulas. The slide rule is more versatile, being applicable to a wide variety of problems, but requiring more settings than the usual nomograph. A third tool, not commonly used, is graph paper, which shares many of the advantages of specificity of the nomograph, while retaining much of the versatility of the slide rule. Methods are shown in this paper, reprinted from the March, 1949, *American*

Journal of Physics, for the calculation of many types of problems, including weighted averages, quadratic and cubic equations, reciprocal sums, proportionality, and products involving fractional powers. The graph papers employed are hyperbolic, linear, semilogarithmic, and logarithmic.

T. W. Kethley, W. B. Cown, and F. Bellinger, *New Test for Gaging Leakage from Frozen Fruits and Berries*, Georgia Institute of Technology, State Engineering Experiment Station Reprint No. 32, 1949. 8 pages. 25 cents.

Research and development in the frozen foods industry have been retarded, in the past, by the dearth of reproducible tests. One needed test is a reproducible means for measuring the leakage which accompanies the thawing of frozen fruits and berries, especially since uncontrolled variables in previous leakage-test procedures probably account for many of the discrepancies in data reported in the literature. To remedy this situation, one phase of the work on the preservation of foods by freezing at Georgia Tech has been devoted to the development of a new leakage-test procedure and method of reporting the results of leakage determinations on frozen fruits and berries.

In this method, reported in the February, 1949, issue of *Food Industries*, a sample of food is weighed prior to, or immediately following freezing, and is sealed in an individual container. Leakage is then determined as the total weight lost during storage and thawing. The latter step is carried out under mineral spirits in a room maintained at 68° ± 1° F. The period selected for thawing is the time for the sample to reach 68° F. plus one hour. Reproducible leakage results may be obtained by use of this method. *B.H.W.*

MODERN SANITARY SUPPLIES

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Moths and their larvæ can be killed by mixtures containing paradichlorobenzene. Many insect powders contain mixtures of DDT, sodium fluoride, sodium silicofluoride, and the like.

OTHER PRODUCTS

Many of the larger sanitary supply houses also carry a complete line of related miscellaneous products and the equipment necessary to sanitation and maintenance. Included among the chemicals are certain specialty items such as various solvent cleaning mixtures for specific uses, permanent-type floor finishes with rubber or synthetic resin bases, deodorant blocks and urinal cakes, carpet shampoos, aluminum and street-marking paint, floor sweeping compounds, and liquid polishes for metal furniture and silverware.

In the category of accessory equipment might be mentioned floor scrubbing and polishing machines, which are great labor-saving devices when large areas are to be maintained, and industrial vacuum cleaners. This category also includes all types of brooms, brushes, sponges, wax applicators, chamois, soap dispensers, dust mops, dust-pans, garbage cans and all types of metal waste receptacles, rubber mats and matting, mop wringing equipment, and certain paper goods such as towels, paper cups, and toilet paper.

Having started from humble beginnings, the sanitary supply industry in recent years has grown to a size where its annual production can be measured in hundreds of millions of dollars, exclusive of the value of the large quantities of similar products consumed in the homes. Progressive companies have taken steps to insure quality products by installing chemical laboratories for control over their production and for constant research and development on new products or new uses. It is those companies which are contributing most to the general improvement in sanitary conditions in plants, factories, offices, and stores. In this manner, they have become an important factor in public health and industrial hygiene.

PHOTOGRAPHY — A VERSATILE RESEARCH TOOL

Continued from Page 4

scribed above, is of great importance in the inspection of finished and semifinished components to show when faulty manufacture has rendered them unserviceable, but it gives no indication of the state of the substance as a whole.[2] However, a very satisfactory method for obtaining an insight into the structure of a substance has been developed in which the sample being investigated is utilized as an X-ray diffraction grating, the X-ray diffraction pattern thus obtained being recorded photographically. By studying such patterns, the composition of which is determined not only by atoms present in the sample but also by their arrangement, a wealth of information concerning the chemical identity of a substance may be obtained. Although X-ray diffraction has been used primarily in metallurgical studies, it appears to be applicable to investigations in numerous fields, including paints, pigments, ceramics, glass, cement, plaster, rubber products, storage batteries, and textiles.[3]

MICROSCOPY

Optical microscopes have been in use for a considerable period of time, and the employment of a camera to record the results obtained by a microscopic examination of a sample is commonplace in many laboratories. However, by combining photography with the use of a comparatively new device, the electron microscope, a new field with tremendous possibilities has been opened. The electron microscope operates on a similar principle to that of the optical microscope, the light source being replaced by a source of electrons and the lenses by magnetic fields. Its principal advantage is the increased magnification obtainable. By allowing the electron image of the sample under study to strike a photographic plate, a permanent record is established which may be enlarged by the methods of conventional photography until a maximum useful magnification on the order of 100,000 times is obtained. This instrument provides the research worker with a powerful tool in investigations of particle size, size distribution, and shape; such studies are becoming increasingly important in the fields of metallurgy, rubber, petroleum refining, and paint.[7]

HIGH-SPEED PHOTOGRAPHY

The development of high-speed photography and of such necessary auxiliaries as sources of adequate illumination have made it possible to arrest motion which is far too rapid to observe with the human eye. This application of photography has been featured to a considerable extent in the popular press; however, it is of considerable use in research work, particularly in the design and study of rapidly moving machines. This technique has also been used on numerous occasions in conjunction with that very versatile instrument, the oscillograph.

PROFILOGRAPHY

Sensitized film plays a part in an useful instrument known as the profilograph, a device capable of measuring the smoothness of a surface. This instrument consists essentially of a vertical pinpoint with a mirror attachment, under which pinpoint the surface to be examined is moved slowly. A ray of light from a fixed source strikes the mirror and is reflected to a photographic film located some distance away. The variations induced in the movement of the pinpoint by irregularities in the surface under examination are thus magnified and recorded for future study.[8]

INFRARED PHOTOGRAPHY

Photographic emulsions have been developed which are sensitive to those radiations lying in the range 7,000–10,000 A (usually referred to as the photographable portion of the infrared spectrum). The advantages of infrared photography over visible photography are derived from the fact that infrared radiations are less easily scattered than visible light. Although infrared photography has been used, for the most part, in such nonresearch fields as aerial mapping and long-distance landscape photography, it has also been applied success-

fully for the determination of the surface temperature of hot objects,[4] for studying conditions inside of burning furnaces, for the recording of stars hidden by the luminous haze of nebulæ, and in studying the porosity of plating in the tinplate industry.[2] Infrared spectroscopy has also been utilized successfully on a number of occasions. A novelty aspect which is frequently used to advantage is the employment of infrared photography to record pictures of totally dark scenes, the source of radiation being a hot, but nonluminous body.

GEORGIA TECH PHOTOGRAPHIC LABORATORY

The Photographic and Reproduction Laboratory of the Georgia Tech Engineering Experiment Station was established on July 1, 1947, to fill an urgent need for a wide variety of photographic and related service. The equipment, facilities, and personnel of the laboratory have been expanded steadily since that time in order to support the diverse research program carried on at Georgia Tech.

Facilities for the laboratory have been provided by converting a medium-sized building into a series of studios, work rooms, and three dark rooms. These dark rooms, which of course are the heart of the laboratory, are air conditioned in order that optimum temperatures for the processing of film may be maintained at all times. Another dark room which is available to personnel of the Photographic Laboratory is located in the main research building of the Experiment Station; this room is primarily used for the processing of color film, and its temperature is capable of being controlled to a fraction of a degree.

EQUIPMENT

In addition to the cameras used for routine photographic work, a number of special pieces of equipment are available. These include a camera manufactured by the General Radio Corporation, which may be used in conjunction with a Strobel flash unit for making split-second exposures, and a Western Electric Fastex high-speed motion picture camera. This latter camera is capable of making pictures at a speed of 4,000 frames per second. Two other cameras which are in wide use are a Dumont strip camera and a Fairchild scope camera. These cameras have proved to be well adapted to the recording oscillograph traces.

Other equipment on hand in the Photographic Laboratory includes the usual assortment of printers, enlargers, driers, layout tables, etc. Of these, two are of more than passing interest, namely, a Hunter Copyflex printer and an engineering photostat machine. The Hunter Copyflex, which is used to a considerable degree in reflex photography, is capable of handling a 40" x 36" negative; therefore, it is also utilized for making large-sized contact prints. The photostat machine is capable of making prints as large as 14" x 17½", and its value is enhanced by the fact that drawings, sketches, and other figures can be reproduced accurately to scale.

In order to facilitate certain types of reproduction work which does not require the use of photography, the laboratory is equipped with an Ozalid machine which, through the use of a simple ammonia process, is capable of producing prints in any one of four colors — red, sepia, blue, and black.

APPLICATION TO RESEARCH AT GEORGIA TECH

Although many of the applications of photographic processes to local research problems cannot be revealed, even in general terms, because of contractual obligations to research sponsors, it is believed that the following represents a sufficiently accurate cross-section of such activities to present a reasonably complete picture of the role that photography is playing in research at Georgia Tech.

Dry Battery Research.[5] Under the auspices of the Signal Corps, U. S. Army, the production of synthetic MnO_2 for use as a depolarizing agent in dry batteries has been under investigation for the past three years. In an effort to substantiate certain conclusions which have been deduced from the most modern theories covering the mechanisms of dry cell discharge, the structures of a number of MnO_2 samples which were synthesized during the course of this project have been determined through the use of photographic recordings of electron microscope and X-ray diffraction studies.

Low Temperature Research. In a current investigation of the properties of the rare earths at temperatures only a few degrees above absolute zero, a project sponsored by the Office of Naval Research, the purity of the samples being studied has been of considerable importance. Very valuable data concerning the composition of these samples have been obtained from spectrographic data, which, of course, was recorded on photographic film. In the same investigation, powder X-ray diffraction techniques have been employed to gain needed information concerning the structure of a number of these elements.

Preservation of Foods by Freezing. A long-standing project at Georgia Tech, sponsored jointly by the Georgia Tech Engineering Experiment Station and the Tennessee Valley Authority, is concerned with the determination of fundamental data covering the preservation of foods by freezing. In this investigation, considerable emphasis has been placed upon the recording of the physical characteristics of foods in order to determine what changes, if any, are brought about by the freezing process. One of the most important physical characteristics of food is its color, a property which may be most appropriately determined through the use of color photography. Although a number of other methods were tried, the preparation of color transparencies proved to be the most satisfactory way to record the results of these studies.[6]

There are numerous other projects in which photography is being used. It is employed extensively as a recording medium in wind tunnel tests and in the hydraulics laboratory. In an electronics investigation, considerable data are obtained by means of an oscillograph; these data are recorded for future study by photographic means. An emulsion study has required the determination of the diameters of some very small particles, as has an ærosol investigation; electron micrographs are providing the keys to those particular problems.

In addition to the applications described above, photography is used continually in the preparation and reproduction of the numerous figures, graphs, drawings, etc., that are required for the preparation of the reports which are submitted periodically to research sponsors, for the preparation of articles which are forwarded to scientific journals, and for many other purposes.

As may be seen, photography has been applied to a number of research problems at Georgia Tech. The results which have been obtained cannot be credited to any one group, as many of the research workers are capable photographers in their own right. However, personnel of the Photographic Laboratory have been called upon on numerous occasions for advice, recommendations, and technical assistance. Thus this laboratory, serving as a focal point for all photographic activity at Georgia Tech, is contributing to the advancement of the frontiers of scientific knowledge, and, in particular, to the solution of numerous complex problems, many of which are of vital interest to Georgia and the South.

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FINE PARTICLES RESEARCH AT GEORGIA TECH

Continued from Page 6

as to size. A plot of the frequency with which the different sizes occur, as determined by microscopic measurement (Figure 2), reveals the reason for the dissimilarity of the two samples. It will be seen that while both samples have the same average

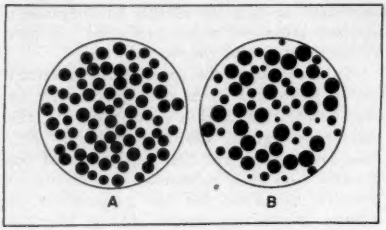

Figure 1. While Samples A and B both have the same "average" diameter, since both were passed separately through a given screen and retained on another screen of smaller dimensions, these samples show distinct differences in size distribution.

diameter, Sample A has many more fine particles than does Sample B.

The above examples, while simple, serve to illustrate why some confusion exists in the interpretation of much published data and why great care must be exercised in obtaining measurements of particle size which bear directly on the problem under study. The most exacting methods of surface measurement of particle aggregates based on adsorption yield nothing more than surface per unit volume or unit weight. A so-called average diameter can be obtained by an easy calculation, but it expresses little more than an order of magnitude, yet this is for a method as absolute as has thus far been developed. The average diameter obtained assumes the particles to be spheres or cubes when actually they are quite irregular. It is timely, then, to note how important shape really is.

Let it be assumed that the diameters of a representative sample of particles, all irregular in shape, have been measured by some microscopic method. By "diameter" in this instance is meant the projected length of particles measured in one and only one direction. Assuming that there are N of these particles, of average diameter d, the volume of these particles equals Nd^3 if one assumes them to be cubes or $N(\pi/6)d^3$ if one considers them as spheres. The difference is considerable, in the ratio $6/\pi = 1.91$; that is, the volume of the particles computed as cubes is almost twice that if computed as though they were spheres.

We have no right, however, to say that an irregular particle on the average is more often a sphere than a cube; generally it is neither. If as a matter of definition we introduce a general "shape factor," ν, and take the "shape factor" of a cube as unity and that of a sphere as $\pi/6$, then for irregular shaped particle having an average diameter of d, we may write its volume as νNd^3. It actually happens that ν for smooth, well-rounded grains of sand is much less than the shape factor for a sphere and is roughly 0.35. Therefore, it can easily be seen that unless the shape factor is known, a measure of particle volume based on the number of particles measured can be in serious error. The error is magnified many times when one considers surface shape factors in surface measurements. Such factors play an important role in pigment technology and are especially difficult to determine because the particle size dealt with approaches 0.01 micron (10^{-6} centimeters).

These examples may seem trivial, yet most problems which have given trouble to those dealing with fine particles owe their difficulties largely to misconceptions as to the meaning of particle diameter. Micromeritics, however, goes beyond a consideration of what is meant by size. It also considers problems relating to the following items: thermal conductivity; solubility; ab-

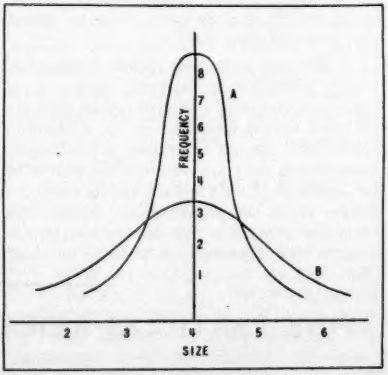

Figure 2. Size distribution curves for the two samples shown in Figure 1. Note that although both samples have the same "average" diameter, Sample A is the more uniform.

sorption and adsorption; ærosol behavior; erosion problems; and control, handling, and conveying of industrial muds and slurries. While the study of each of these problems must be approached by different methods, basic micromeritic tcehniques are employed.

THE GEORGIA TECH MICROMERITICS LABORATORY

In response to a growing industrial demand in this area, a well-equipped laboratory for research in the field of fine particle technology has recently been established at the Georgia Institute of Technology and will be completed late this summer. Every effort has been made to provide all of the equipment necessary for anticipated studies, and a long-range program of fundamental research on micromeritics has been outlined.

Among the problems which can be handled in this laboratory are particle size and surface measurements by any method thus far proposed; utilization and control of mineral products, such as the talc and clays produced in Georgia, materials which are finding increasing use in industry; ærosol studies relating to smoke, dust, and insecticides; investigations of such chemical and physical properties of powders as adsorption, absorption, surface activity (catalysis), consistency, diffusion of gases in packings, and particulate diffusion from stacks and other sources.

It might be mentioned that the purpose of the work contemplated for the micromeritics laboratory relates to service to industry and investigation of those specialized fields in which fundamental data relating to fine particles are needed. Thus, for example, the laboratory will not undertake studies of ceramics or powder metallurgy except insofar as detailed information on the particles used is desired, as, for example, particle size, specific surface, shape factor, wettability, consistency, etc. Only on rare occasions will it be necessary to correlate particulate variables and the properties of a finished product. In the above industries and others already mentioned, emphasis will be placed on such measurements and studies as will bring out the properties of fine particles needed for the control of a desired product or process.

The complex nature of the field encompassed in micromeritics makes it necessary to provide rather extensive laboratory equipment and facilities. During the past year, much of that required for fundamental studies and for assistance to industry has been accumulated or built. Although the present laboratory is now one of the best equipped in this country, plans are in progress to add more equipment as required by further developments in this field.

In addition to equipment needed for making all kinds of particle size, surface or volume studies, provision has been made for investigations on particle physics and chemistry. Consistometry, solubility, reaction rate, and thermal conductivity are but a few of the many factors which the Georgia Tech laboratory is equipped to study.

RESEARCH PROGRAM

It is perhaps in the field of research that the greatest interest lies. The field of micromeritics is new, and many problems are still unsolved. A few now under study here may prove of interest.

First of all, there is urgent need for standardizing the multitude of techniques used for measuring particle size and surface. In this field it is planned to study systematically the various methods being used and to point out the errors involved in each and the significance of the results obtained. The scope of this undertaking is very great indeed, for it will consider methods which are based on dynamic, hydrodynamic, adsorption, electrostatic, and optical properties. The last procedure alone includes no less than ten different techniques, none of which as yet has been properly evaluated.

A second part of the program will deal with the diffusion rates of gases through packings of particles and powders. Rates of diffusion under different circumstances have an important bearing on many chemical and industrial problems, yet this matter has yet to be studied even in its most elementary aspects.

A third program will be devoted to a study of the utilization of Georgia clays and talcs. A good deal of attention has already been given to this subject since these minerals are found in great abund-

ance in Georgia. Georgia clays possess many important properties which may be enhanced when these materials are properly sized and treated. Special emphasis will be placed on treatments designed to improve further their adsorptive and absorptive characteristics.

The fourth program is concerned with ærosol studies. The importance of air-suspended particles as vehicles for condensing gases and the need for controlling many injurious substances has only recently been appreciated. Here is a large field in which few techniques suitable for such an investigation are available. In this connection, mention may be made of a special high intensity sound apparatus which is being developed for the ærosol program and of work on a new device suitable for detecting relatively low concentrations of air-suspended matter in a continuous manner.

The above programs represent the major fields of present interest. However, it must be pointed out that the facilities afforded by the laboratory make it possible to investigate many other problems such as, for example, the fluidized particulate beds now coming into extensive use in chemical engineering operations; powdered fuels; and solid-liquid suspensions.

The Georgia Tech Fine Particles Laboratory is scarcely a year old, yet it has already performed considerable industrial work and has been instrumental in the development of a new process for the treatment of clays used in insecticides. This laboratory constitutes a new and valuable tool which should aid Georgia Tech in its long-standing program of service to industry and in its search for knowledge.

UNIVERSITY RESEARCH

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necessary assistance is not elsewhere available: to make available unique facilities; to aid in the development of natural resources and the industrial advancement of their regions by assisting existing industries and aiding in the formation of new ones.

In addition to these primary goals, it has been noted that the performance of industrial research on the university campus also provides an opportunity for the professional training of budding scientists and engineers. As Blake R. Van Leer has put it, "How are educational institutions going to train research workers for industry unless they are given a reasonable amount of actual research to perform"?

University engineering experiment stations have access to an unusual reservoir of scientific and engineering personnel. Many companies cannot afford to retain the services of men trained in the many fields concerned with technological education, yet a university engineering experiment station can readily call in for consultation or project direction members of the faculties of any of the university's colleges and schools. Moreover, many such university industrial research groups have sizable full-time staffs of engineers and scientists who round out their personnel potential.

The well-operated engineering experiment station is under no handicap when it comes to obtaining basic apparatus and supplies. Moreover, the value of special equipment for both educational and research purposes has spurred some universities to acquire electron microscopes, mass spectrometers, X-ray diffraction equipment, spectrographs, etc., and to equip elaborate machine shops.

Every technological institution of higher learning is vitally concerned with the search for fundamental knowledge — through graduate research, departmental research, and those basic projects which are sponsored by experiment station funds. In addition, however, these institutions are convinced that they must use their abilities and interests also to serve industry directly, through industrial research, as well as indirectly through education and general advancement of knowledge.

TEXTILE THESES

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during which the concentrations were varied to determine the exact procedure for producing optimum conditions in the sized yarn. From the results of these tests, it was concluded that, on an experimental basis, single cotton yarns can be sized at the spinning frame during the twisting operation, thereby producing weaving yarns of good qualities. *E.P.C.*